Renewable ENERGY project spotlight

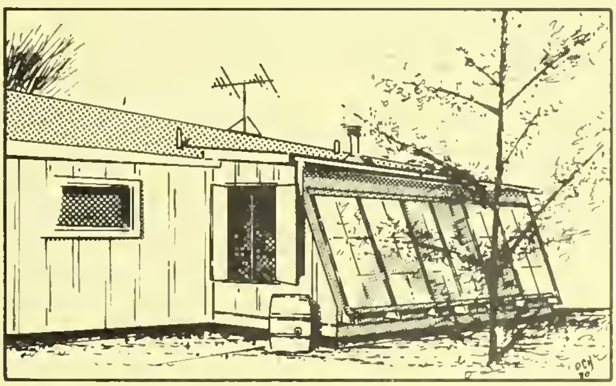
MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
RENEWABLE ENERGY PROGRAM
ENERGY PLANNING DIVISION 32 SOUTH EWING HELENA, MONTANA 59601 DNRC

PASSIVE SOLAR GREENHOUSE WITH WOOD HEAT

LOCATION: South 6th Avenue in Great Falls.

PURPOSE: To provide space heating for the home and an environment for growing food on a year-round basis by constructing a solar greenhouse on the south side of the home and installing a woodburning stove which will work in conjunction with the greenhouse to heat both units.

PROJECT: A 10 foot by 24 foot solar greenhouse was constructed on the south side of the home using 2 by 6 framing and insulated with 4-inch styrofoam and 2-inch blanket insulation in the floor, walls and ceiling. Kalwall Sun-lite double fiberglass glazing was used on the south side of the greenhouse structure. Solar heat entering the greenhouse is stored in 12, 50-gallon water-filled barrels located along the back wall. Heat circulation between the house and greenhouse is through the pre-existing windows and door. Vents along the east and west ends can be opened to provide fresh, cool air during warm weather.



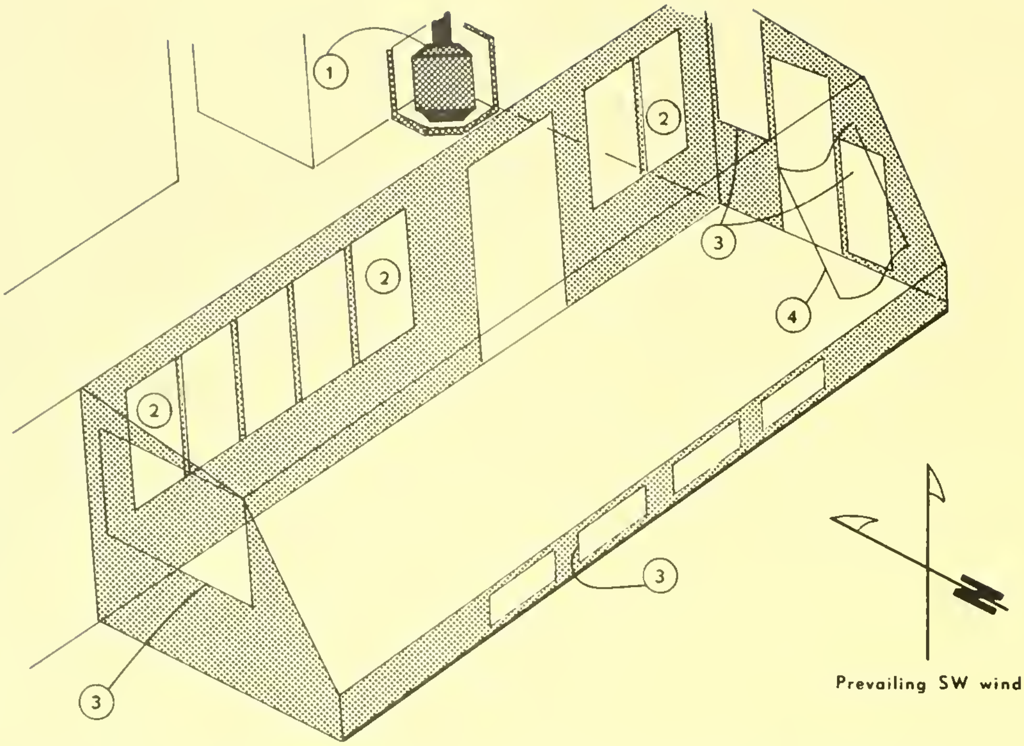
A Jotul Comi-Fire woodburning stove was installed at the east end of the living room, which is adjacent to the greenhouse, for backup heating needs. A 20-inch electric fan, mounted between the house and greenhouse and adjacent to the stove, can be used to blow cool greenhouse air past the stove for warming during cloudy periods or at night. The warmed air returns to the greenhouse through the vents and windows.

MODIFICATIONS: To reduce the cost of construction, Kalwall Sun-lite double fiberglass glazing was substituted for the double-paned glass originally planned. Masonite and styrofoam movable slat insulation, which would operate like a roll-top desk, was originally planned to cover the greenhouse glazing area at night or during cloudy periods to reduce heat loss. Because of the potential for heat loss through the cracks between the moveable slats, polystyrene bead board with magnetic clips was installed instead.

SYSTEM PERFORMANCE: The highest fuel bill for the first winter of operation (1977-78) was $30. When the owners left the house in the care of someone else during the month of January 1979, the heating cost rose to $70, leading to the conclusion that correct monitoring and use of the system is necessary to keep cost down. The greenhouse provides all sunny-day heating for the house and gathers and stores enough solar heat to carry through the night. Evening and overnight heating for the house and greenhouse is mostly provided by the wood stove. The natural gas furnace is used for any additional heat needs.

ECONOMIC EVALUATION: The owner estimates that the greenhouse will provide 129,000 BTUs/square foot per day and require only 45,000 BTUs/square foot per day for heating. The additional 83,700 BTUs can be viewed as a heat cost saving of $220 per year based on 1978 natural gas prices. The owner also estimates a $260 per year savings for food grown in the greenhouse. These savings will reduce the initial cost of the project from $5,126 to $4,646 with a payback period of 5.7 years. Interest is not included in the computation; owner-gathered firewood was assumed with no allowances made for labor or expenses. Maintenance costs for the stove or growing space were not included. If the greenhouse and stove were installed by a contractor, it would raise the cost to $12,000.

VIEWING TIMES: The greenhouse can be seen by arranging a mutually agreeable time with Gary Franklin at 727-7661 or 761-0645 after 6 pm.



(1) Woodburning stove to provide auxiliary heat during winter or when needed for both the greenhouse and home.

(2) Living room windows which can be used for additional venting of the greenhouse.

(3) Vents and doors for summer cooling

(4) Indoor sliding curtain for covering glass area during night time or extended cloudy weather to prevent heat loss.

NOTE: Florescent light fixtures are to be installed to provide growing light to the plants during extended cloudy periods.

GREENHOUSE	
Floor area:	240 square feet
Wall Construction:	2" × 6" wall construction with 4-inch styrofoam insulation
Glazing:	Kalwall Sun-lite double fiberglass
STORAGE	
Medium:	Water
Container:	12 50-gallon drums, painted dark green
BACKUP HEAT	
Jotul Comi-Fire 4 wood stove	

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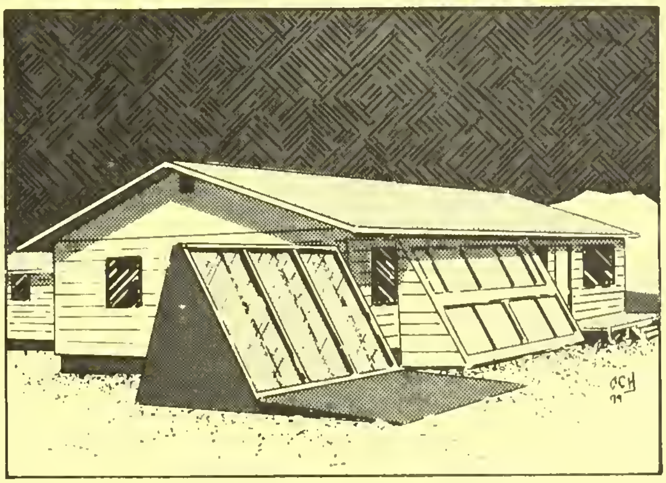
MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
RENEWABLE ENERGY PROGRAM
ENERGY PLANNING DIVISION 32 SOUTH EWING HELENA, MONTANA 59601 DNRC

Active Solar Space and Water Heating

LOCATION: Two miles west of Highway 93; north of Hamilton.

PURPOSE: To demonstrate that household space heating and domestic water heating can be supplied by solar energy. The project was designed for a new home consisting of 1,377 square feet.

PROJECT: The home was designed to use a complex space heating system incorporating a heat pump with a separate backup resistance heating unit and a hot air solar collection system. Each of these heating sources can operate together or independently, which accounts for this system's complexity.



The solar air collector is a Sunglow Model 96 by Champion. The absorber plate is an aluminum sheet with aluminum beer can type cylinders attached at spaced intervals to increase the exposed surface area. The absorber plate and cans are painted flat black to increase heat absorption, and the collector is glazed with double-pane glass. A rock storage area is located directly behind the collector; a fan circulates air from the collector to the storage area. The solar collector is located 15 feet from the home and connected to it by underground insulated ducting. A fan in the collector/storage module works with the fan in the forced air heating system to bring solar heated air into the home's forced air heating system. A cold air duct returns cool air from the home into the storage area.

A heat pump, which includes a backup resistance heating unit that can operate independently of the rest of the system, will be used as an auxiliary system for space heating when heat from the solar unit is insufficient. It is connected so it can operate automatically when the preset minimum temperature is reached.

The domestic hot water system is built into the south side of the home. The collector consists of double sliding glass windows mounted at a 60-degree angle. Behind them are stainless steel absorber plates, backed by insulated board. Heating tape attached to the bases of the absorber plates prevents freezing. The tapes are thermostatically controlled and will switch on when the temperature next to the collector absorber plates reaches 35 degrees F. The collectors heat water which is circulated by a pump into two well-insulated 42-gallon tanks that are connected in series to a 52-gallon hot water heater.

SYSTEM PERFORMANCE: Several monitoring devices were installed, including temperature probes, elapsed time counters and strip chart recorders, to accurately determine the system's performance. The measured performance of the system between July 1977 and December 1978 was:

Domestic hot water system
4,290 BTU/kWh
Air heating system
5,470 BTU/kWh

These should be compared to the following conventional heating sources:

Electric hot water heating	2,000 BTU/kWh
Electric resistance heating	2,400 BTU/kWh

From July 1977 through June 1978, the solar space heating system operated at an efficiency of 46 percent and the solar domestic hot water system performed at a 28 percent efficiency. These amounts represent the total solar heat delivered to the home compared to the total solar energy available.

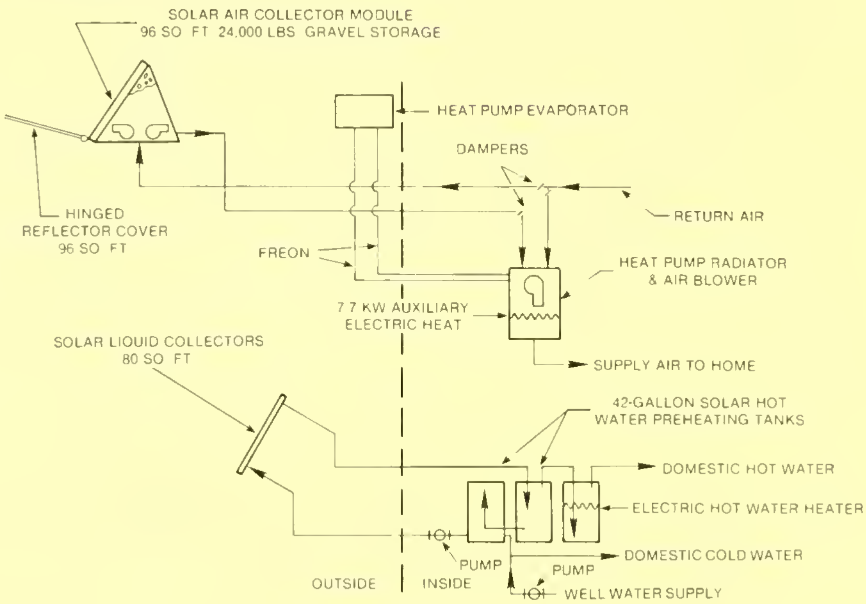
During the same period, total household heat demand for space and water heat was 63 million BTUs, of which solar heaters provided 26 percent, the heat pump 51 percent and electric heaters 23 percent.

MODIFICATIONS: After installing the double sliding glass windows at a 60-degree angle, the grantee discovered that at this angle, the seals of the windows and the metal lip around the window frame would not drain water off the window properly, resulting in leakage into the home. To prevent this leakage, a system of plastic manifolds and drain gutters was installed.

The grantee also tried routing the solar heated air which was not warm enough for use in home heating (70°F) through to the heat pump, in hopes that it would allow the pump to operate at a higher efficiency. Since the heat pump was not in a completely sealed container and was located outside the home, the solar heated air routed to the pump dissipated before having a significant effect on the pump's operation and therefore did not warrant the extra effort. After a short trial period, this idea was dropped.

ECONOMIC EVALUATION: According to the grantee's calculations, at 1977 oil prices ($.50 gallon), the completed project would not be economically competitive with conventional oil heating in a similar house. The project delivers heat at about $50/million BTUs, versus $37/million BTUs for oil (assuming a 30-year system life and a 30-year loan at 9.75 percent to finance). These figures take into account all tax advantages, insurance, maintenance, etc. The high cost of purchased solar collection components is the main excess expense. However, compared with energy costs for 1975-76 in a former home of like size, the project saved $186 in 1977-78. (This figure includes non-heating electrical use).

VIEWING TIMES: By appointment only after 1:00 p.m. by calling Gail Owen at 363-2549.



HOUSE	
General:	New dwelling; no open combustion in household energy system
Floor area:	1,377 square feet
Framing:	2 inches by 6 inches with 24 inches between studs
Window area:	155 square feet (triple glass)
Insulation:	
Walls, floor:	6 inches (fiberglass)
Ceilings:	12 inches (fiberglass)
Estimated heat loss:	7,020 BTU/degree day (July 1977-Dec. 1978 avg.)
COLLECTOR	
Domestic hot water system:	
Transfer fluid:	Water (1.5 gpm; 0.89 gph/sq. ft. collector; 136 gallon storage)
Size:	80 square feet stainless steel absorber plates
Tilt:	60 degrees from horizontal
Orientation:	True south, framed into the wall of the structure
Space heating system:	
Collector:	Solarthermic/ISC Sunglow Model 96 by Champion Mobile Homes
Area:	96 square feet air collectors, 96 square feet reflector area
Backup heating:	G. E. Weathertron 30,000 BTU/hr heat pump with a 7.7 kW resistance heating unit
Transfer fluid:	Air (750-1100 cfm; rate varies with operating mode)
Collector to storage ratio:	250 lbs/square foot

Renewable ENERGY project spotlight

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
RENEWABLE ENERGY PROGRAM
ENERGY PLANNING DIVISION 32 SOUTH EWING HELENA, MONTANA 59601 DNRC

Active Solar Space Heating

LOCATION: River Road, about two miles southwest of Glendive, MT.

PURPOSE: To retrofit an existing house with a simple commercially available solar heating system, and to show that such a supplementary system can save the homeowner a substantial amount on fuel bills. Most of this project could be accomplished with construction skills possessed by the average home handyman.

PROJECT: For this 928-square-foot home, eighteen years old, it was decided that a collector system separate from the house should be used, because the house is shaded much of the year and there are trees and a garage on the south side. The orientation of the house also precluded the installation of collectors on the structure. The solar unit, a Champion Model 160, uses five 4' X 8' air collector panels with a cover that acts as a reflector when open.

Two blowers transmit heat from a 15-cubic-yard storage bin through an insulated duct into the return air ducting of the natural gas furnace. A differential thermostat that responds to temperature variations in collector, rock storage, and house controls the blowers. Whenever heat is greater at the collector than at the storage bin, a fan will transfer the heat to storage. When heat is called for by the house thermostat, and there is sufficient heat in the bin, another fan will blow air through the rock bin and into the house.

The original house insulation was 3½" in walls, and 6" in ceiling. Fiberglass insulation was added to the attic two months after the solar unit started operating, making the total attic cover 12" with an R value of 39. Caulking and sealing done by the owner were considered essential to the effectiveness of the new supplementary system.

MODIFICATIONS: To avoid continuous use of the gas furnace blower, the grantee substituted a relay which activated the house furnace blower on demand, rather than continuously. The size of the rock for the storage bin was changed from the recommended 1½-2" size to a mixture of large (2-6") and medium (½-2") rocks to increase the average size of the rock. It now appears that it would have been better to use all large rocks because the large/medium mixture does not allow adequate air flow. The rocks were washed to reduce dust coming into the house from the blowers.

SYSTEM PERFORMANCE: The solar unit operated well on sunny days, with warm air ducted into the house acting as a supplement to natural gas heat. Due to cold and cloudy weather in the brief initial test period, not much solar energy was received by the collectors. The system gave a heat assist during a sunny but cold (high of -19 degrees F.) winter day, by preheating air to the furnace.

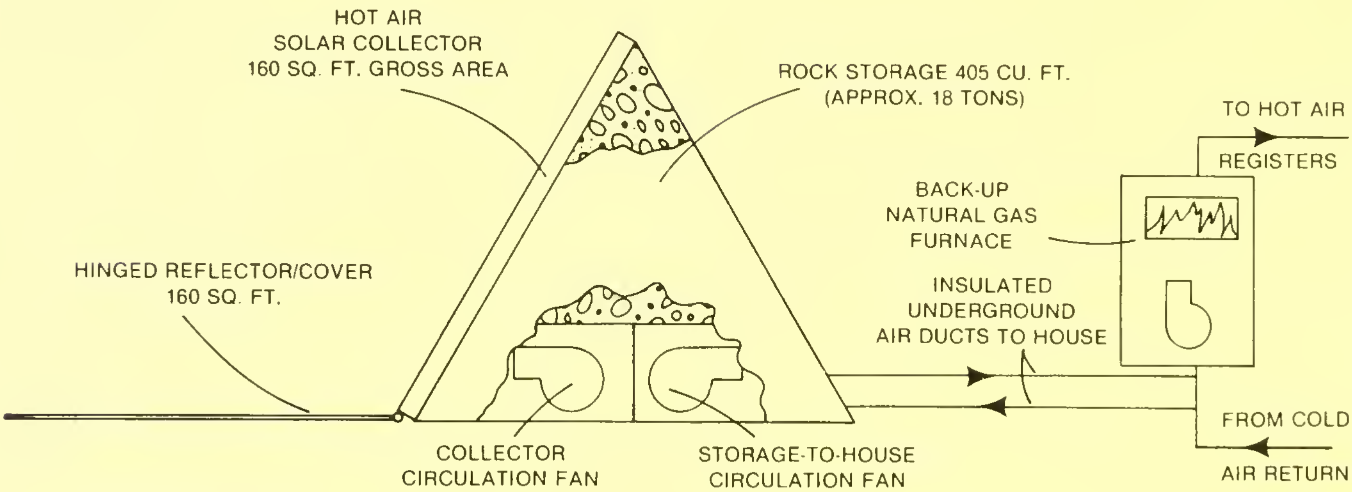
ECONOMIC EVALUATION: The solar unit, installed on the site, cost $5,578. Other expenses include framing for reflector, 80 feet of insulated ductwork to carry heat to the house, a 20-amp electrical circuit, and the rock for heat storage, which can be obtained locally.

The savings over gas heat were negligible, and electrical costs rose due to the added circuit for the

blowers, so the unit can hardly be termed an unqualified success. With more sunny weather and a longer test period, the grantee had hoped that results would show savings in space heating costs of around 55 percent per year. The 1976-77 heating season bill was $194.44 (September 76 - May 77 gas and electricity) before the solar unit was installed in November of 1977. The utility bills for September 1977 - May 1978 had risen to $320.62, partly due to increasing utility rates and partly because of an almost double consumption of electricity. There is a slight decrease (10%) in natural gas consumption for the 1978-79 season (compared to 1976-77) and electrical consumption has been slightly reduced from the 1977-78 level because constant circulation was eliminated and the controls are more judiciously set.

The unit started operation so late in the heating season of a very cold, cloudy winter that economic comparisons with the previous mild winter show no savings. The grantee is still optimistic and believes payoff in 20 years is reasonable. However, the extra electrical consumption is a concern, and if electrical prices increase as natural gas prices do, any system savings could well be reduced.

VIEWING TIMES: The system can be examined after 5:00 p.m. most days. Appointments for viewing should be made by calling 365-2261 or by writing to Dennis Howard, River Road, Glendive, MT 59330.



HOUSE	
General:	one-story, two-bedroom single-family house, full unfinished basement, normal frame construction.
Floor area:	900 square feet
Calculated heat loss:	9690 BTU's per Degree Day
COLLECTOR	
Manufacturer:	Champion
Tilt:	60 degrees
Orientation:	South
Location:	on ground, 40 feet from house
Construction:	double glazing, flat plate, factory-produced beer-can type absorber plate; air passes between glazing and absorber plate.
STORAGE	
Medium:	Mix of ½-2 inch and 2-6 inch washed rock
Container:	A-frame supporting collectors, 6" insulation, lined with sheet metal, 15 cubic feet.
Relation to Collector:	76 pounds rock per square foot collector area.

Renewable ENERGY project spotlight

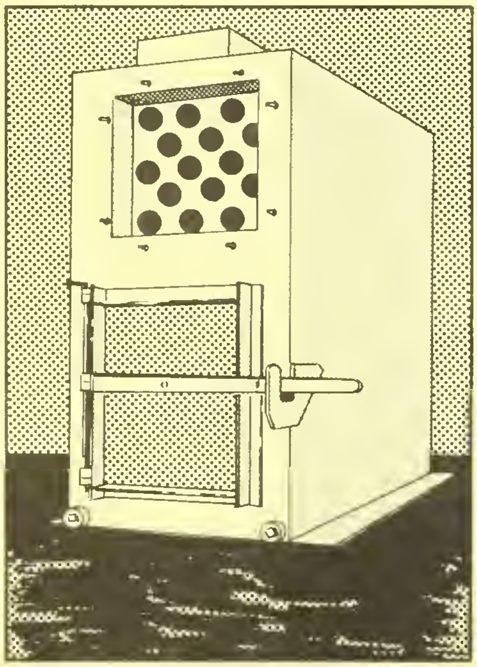
MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
RENEWABLE ENERGY PROGRAM
ENERGY PLANNING DIVISION 32 SOUTH EWING HELENA, MONTANA 59601 DNRC

High Efficiency Wood Boiler

LOCATION: 11 miles northeast of Bozeman, Montana, in Bridger Canyon.

PURPOSE: To design, construct, and test a wood-fired boiler and a heat storage unit to heat a single-family dwelling.

PROJECT: The boiler heats a 1,682 square foot, single-story home with a full basement. The home incorporates many energy conservation features including 6-inch wall insulation, 12-inch ceiling insulation, and R-19 steel doors with a magnetic seal similar to that on a refrigerator door. Baseboard electric resistance heating is used for backup heating.



The boiler contains two different sections: the fire box, a square steel unit, and the fire tubes, long steel cylinders suspended horizontally over the fire box.

The fire box (excluding the door) has a water jacket that connects to the water reservoir around the fire tubes. Three inlets are fitted at the base of the boiler for cool water returning from the heat storage unit and one outlet is located at the top of the boiler near the flue to allow heated water to move by convection to the storage tank.

Steel access doors can be removed so that soot can be cleaned from the fire tubes. To prevent the doors from warping, they were lined with ½-inch asbestos. The doors and firebox were also reinforced along the edges with angle iron.

A heavily-insulated heat storage tank, located next to the boiler in the basement, can supply heat for as long as a day and a half when the outside temperature is -29°C (-20°F). Water is circulated between the boiler and storage tank by thermosiphon through 3-inch pipes.

Hot water from the storage tank is distributed through the house for space heating. The heat storage tank is connected to a manifold and a series of distribution pipes that feed three separate heating zones in the home. The first zone includes the family room and utility room, the second the living room and entryway, and the third the master bedroom. In addition, coils of pipe laid in the concrete-rock floor of the entryway serve as a radiator. A valve connected to the distribution pipes in each zone is used to adjust heat flow. Conventional fin tube radiators connected to the distribution pipes provide space heating in each zone. Unlike standard baseboard heaters, these are suspended under the floor joists. The heat radiates through the floor to the room above, deflected by insulated batts stapled on to the joists under the fin tubes. The water is carried to a return manifold and the circulation pump returns it to the heat storage tank.

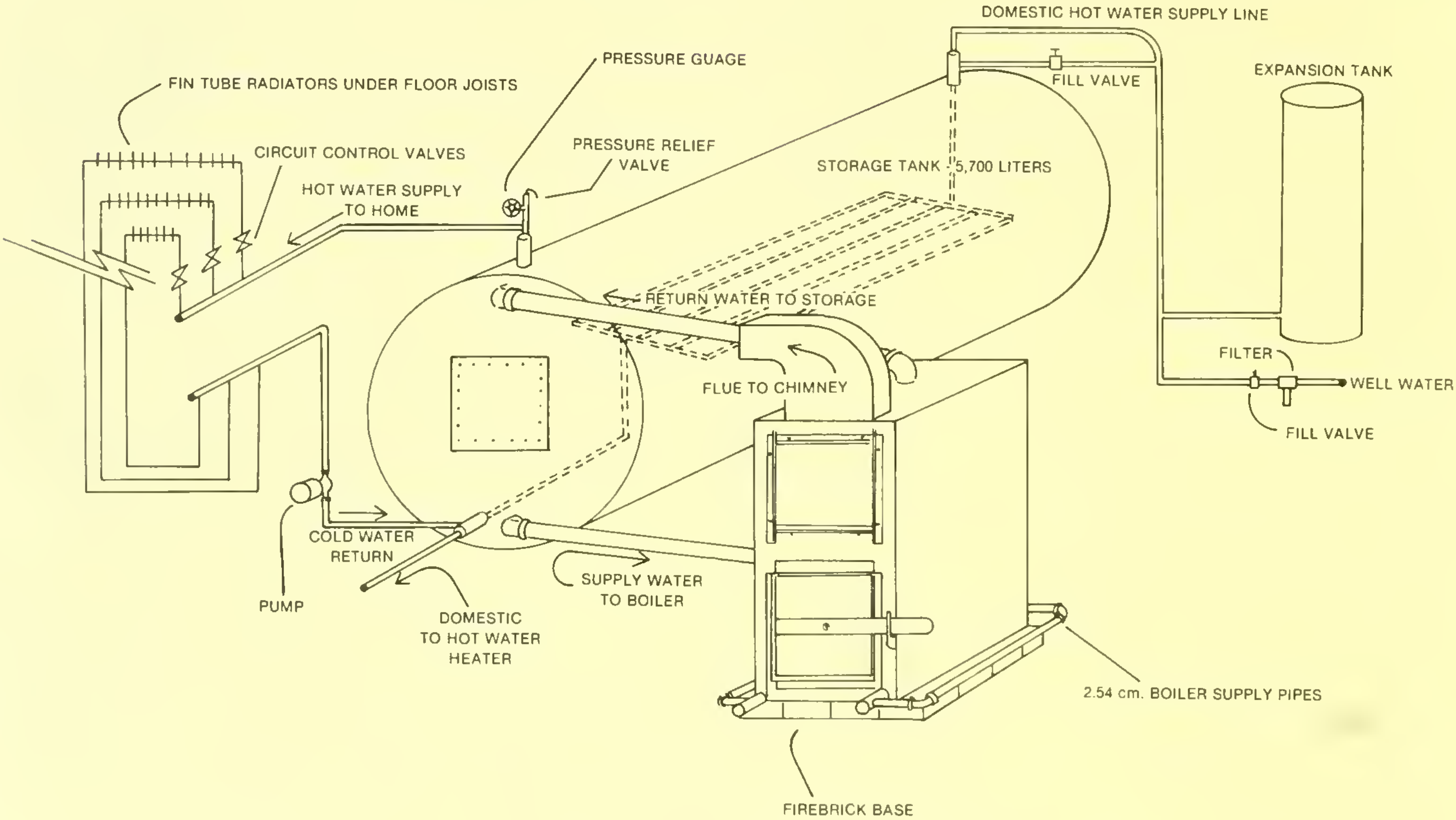
MODIFICATIONS: The original design for the boiler was a cylinder inside a larger cylinder. This system lacked enough surface area for heat absorption, so it was replaced with a square box with fire tubes to increase the area available for heat transfer. An additional modification was made to run the domestic hot water supply pipe through the 1500-gallon storage tank to the electric hot water heater. In this way the boiler pre-heats all domestic hot water to near or above accepted temperature.

SYSTEM PERFORMANCE: During the five-week test period, the two heating systems (wood and electric) were used alternately for a week at a time. The home's temperature and fuel consumption were monitored

throughout this period. Adjustments in the data were made to exclude a two-day period between fuel changes to allow for dissipation of any residual heat. The heat delivered to the home compared to the fuel energy potential of the wood furnace was 55 percent. Twenty-eight percent of the heat obtained for the home came from sources other than the wood and electric heating systems, such as passive solar gain through windows and heat from home appliances and lighting.

ECONOMIC EVALUATION: Using the current rates for both electricity and wood, a cost comparison was made of the energy sources used in this study. The cost per kilowatt-hour of electricity was $.0210 and the cost of wood—in this case lodgepole pine—in sufficient quantity to produce 3,413 BTUs (or one kilowatt-hour) was $.0059. From this, the owner has estimated that he will save $321.35 per year on electrical expenses by using the wood system based on mid-1978 electrical rates and cord wood prices. Total cost of the wood boiler system was $6,561.08, including labor at an average cost of $7.00 per hour plus materials. The simple payback period is 20 years.

VIEWING TIMES: The system can be examined by appointment by contacting Doug Polette at Montana State University, Bozeman, Montana 59717. Telephone (406) 994-3201 or 586-5768.



HOUSE	
General:	One-story, two-bedroom, single family residence, full unfinished basement
Floor area:	1,682 square feet
Wall Construction:	2 in X 6 inches in frame construction
Calculated Heat Loss:	4.81 kWh per degree day °C (9,123 BTUs per degree day °F)
WOOD FURNACE	
Fire box:	2 ft X 2 ft X 4 ft made of ¼ in. rolled steel. Heat absorption area is 28 square feet
Fire tubes:	2 in. diameter and 33 ft length made of ¼ in. rolled steel. Heat absorption area is 39 square feet
STORAGE	
Medium:	1,500 gallons of water
Container:	4 ft diameter and 16 ft length

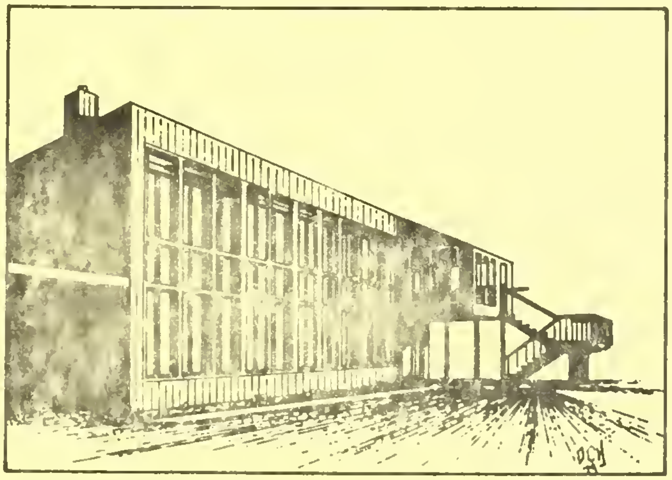
Renewable ENERGY project spotlight

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
RENEWABLE ENERGY PROGRAM
ENERGY PLANNING DIVISION 32 SOUTH EWING HELENA, MONTANA 59601 DNRC

Passive Solar/Wood Space Heating
Active Domestic Hot Water Heating

PURPOSE: This new two-story home was designed and constructed so that over 65 percent of the space heating load will be met by the passive heating system in combination with the wood furnace. On a yearly average. 75 percent of the domestic hot water should be supplied by an active solar system.

PROJECT: The passive heating operation in this house was developed from the Trombe Wall system concept. A row of water-filled fiberglass tubes have been placed about a foot behind the south-facing vertical glass wall to act as the thermal storage device. When the sun is low on the horizon, sunlight passes through the glass and directly warms the tubes filled with water. The heat stored in these tubes is slowly transferred to the surrounding air in the home, setting up natural convection currents to keep the house warm.



During average winter weather this thermal mass can store up to three days' heat requirement for the house. This provides sufficient reserve heat to reduce wood furnace operation during cloudy winter weather. A 6-inch-thick insulating curtain can be drawn between the tubes and the glass to reduce heat loss during cold nights and cloudy days. At present, the motor raising and lowering the curtain is manually switched; in the future, an automatic switching device will be incorporated. The curtain works like a window shade; it moves along a set of guides on both sides of the window and seals off the glass wall from the water-filled tubes and interior of the home.

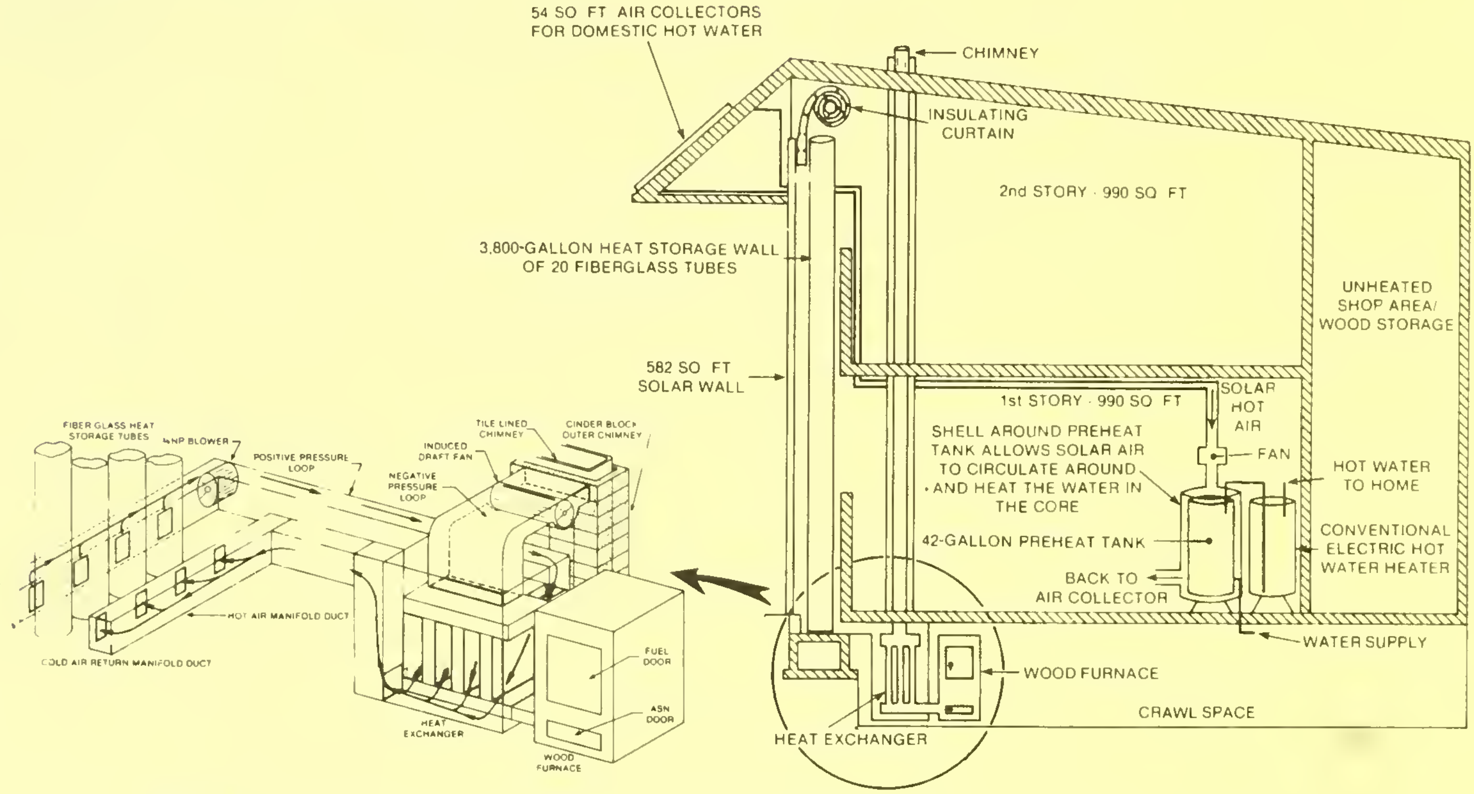
If the solar heat is exhausted, the high-efficiency wood furnace is fired to heat the home. The hot flue gasses from the furnace pass through a tube-type heat exchanger at a negative air pressure and into the chimney. A cold air return manifold draws air from around the bases of the fiberglass water tubes and into a fan that blows air at a positive air pressure through the furnace heat exchanger and back to the bases of the tubes. The warm furnace air can heat the home directly and any excess heat can be stored in the liquid tubes for use at a later time. The pressure differences in the furnace heat exchanger guarantee that no flue gases will be circulated into the home

During summer, the sun is high above the horizon during most of the day and a large percentage of the sunlight is reflected off the glass wall. The insulating curtain is left up from May through September and surprisingly there is no significant overheating during the summer. The thermal mass of the tubes moderates the temperature in the summer. The curtain is never closed if the sun is shining, as the high temperatures might damage it. A domestic hot water preheater is currently under construction. Solar heated air will be ducted from 54 square feet of roof-mounted collectors to a heat exchanger tank. A fan will circulate the warm air through the tank's shell, transferring heat to the 42 gallons of water in the core. Hot air from the wood furnace will also be ducted through the heat exchanger tank. The hot water will then be piped to the conventional hot water heater for home use.

SYSTEM PERFORMANCE: The home was first occupied in September 1977. The major portion of the construction of the insulating curtain, storage wall and wood furnace were carried out during the next three months. During 1978 from February 12 to November 11, the house was heated entirely by the sun. During the winter of 1978-79, slightly over one cord of wood was used for auxillary heat. The first furnace fire was on November 11, 1978 and the last one on January 26, 1979, with a total of 16 fires during this winter. The inside temperatures in this house average about 65-68 degrees. The temperature fluctuates about 10 degrees depending on the amount of solar radiation and outside temperatures. Overheating (contrary to common intuition) occurs not in the summer, but on warm sunny days in September and October. Last fall, this excess heat was circulated through the shop area using the wood furnace fan.

ECONOMIC EVALUATION: All labor was donated by the grantee. Material costs were: passive solar system, $8,326; wood furance, $1,702; and solar domestic hot water system, about $700. In addition to the $10,000 DNRC grant, the grantee spent $3,000 plus the donated labor.

VIEWING TIMES: This home may be seen by arranging a mutually agreeable time with Charless Fowlkes at 587-3779.



HOUSE	
General:	New two-story single family residence
Floor area:	990 square feet per level
Calculated heat loss:	13,200 BTU's per Degree Day
Wall construction:	2 by 6-inch wall construction with 5½-inch fiberglass insulation and plastic vapor barrier
COLLECTOR	
Solar wall area:	582 square feet of double glazed tempered glass (of this, 482 square feet are backed by the heat storage wall)
Wall orientation:	Vertical wall facing true south
Collector area for domestic hot water system:	54 square feet active air collectors (no storage)
BACKUP HEAT:	Wood Furance
STORAGE	
Medium:	3,840 gallons (32,000 lbs of water)
Container:	20 16-inch-diameter tubes, 17 feet long
Relation to effective glass area:	8 gallons per square foot (66 lbs/sq ft)

Renewable ENERGY

project spotlight

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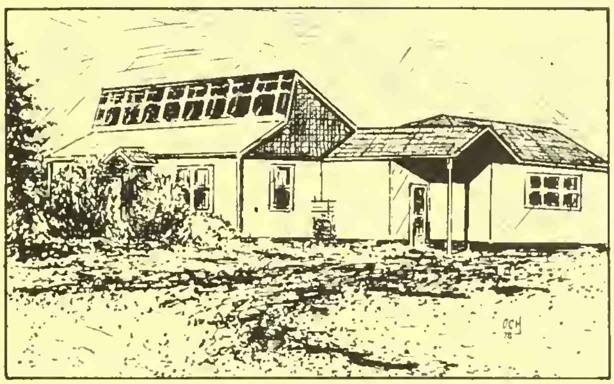
RENEWABLE ENERGY PROGRAM
ENERGY PLANNING DIVISION 32 SOUTH EWING HELENA, MONTANA 59601 DNRC

Solar Space and Water Heating

LOCATION: Three miles west and north of Conrad, Montana on the C.E. Ranch, Incorporated.

PURPOSE: This retrofit project is designed to provide supplementary heat to a residence, and supply domestic water heating. It also demonstrates that the use of a system of reflectors substantially increases the efficiency of a minimal number of solar collectors, and that a satisfactory and reliable heat storage system can be added to an existing house without major structural changes.

PROJECT: The solar collector design was adapted to local weather conditions — strong winds, extreme cold and hail, all of which could damage the collectors or reduce their efficiency. The essence of the design was the housing of the collector array within a south-facing shed, positioned upon the home's roof. The 96 square feet of liquid collectors (tube-on-plate absorbers by Olin Brass) were mounted at a 63 degree angle on the south-facing roof and were protected by double-glazed patio door glass, bought as salvage for less than $125. The shed was built over the collectors by extending the north-sloping roof past the roof peak and over them. The inside of the shed was lined with reflective aluminum sheets, and aluminum-faced shutters lie in the roof in front of the collectors. The shutters can be closed to protect the collectors or prevent heat loss. Altogether there are 450 square feet of reflective surface. The ethylene glycol and water from the collectors passes through coiled copper tubing to transfer heat to fourteen 120-gallon water storage tanks (glass lined). A Deko-Labs Model TC-3 differential thermostat switches the collector pump "on" when the collector temperature exceeds the storage water temperature by a predetermined temperature difference. The thermostat also switches the pump "off" if the collector cools or the storage temperature increases so there is only a 5 degree F. temperature difference.



A number of small tanks were used in order to avoid the problems associated with installing a single large tank in an existing structure. In addition, by simply turning a few valves, it is possible to improve system efficiency by reducing the storage to a size which is more appropriate to the amount of heat delivered by the collectors. When space heat is required for the home, water is circulated from the storage tanks to a water-to-air heat exchanger located in the cold air plenum of the forced air furnace. The stored heat is thus circulated throughout the home by the conventional heating system. The heat transfer mechanism for the domestic water system is somewhat different. In order to avoid contamination of the domestic water supply by the ethylene glycol, the separate 40-gallon preheating tank has the tubing circling it on the outside. This arrangement decreases the efficiency of the preheating tank slightly.

SYSTEM PERFORMANCE: Once installed, the collector system worked well, even though it operated for nearly five weeks without the reflectors. Interestingly, late arrival of material for the reflector system provided a chance to verify one important aspect of the system. Once the reflectors were installed, it was found that even though the hours of sunlight were shorter, collection time was longer. During the day in which the reflectors were installed, the system collected heat for 7.8 hours — the longest time in over a month.

The shed operates as planned, and protects the collectors from snow and wind. On clear days during December, 1977, operation times were often 6.5 hours or more. Daily operation averaged about 3.5 hours per day from October 20, 1977 to January 14, 1978, the period of the year having least sunshine at this latitude.

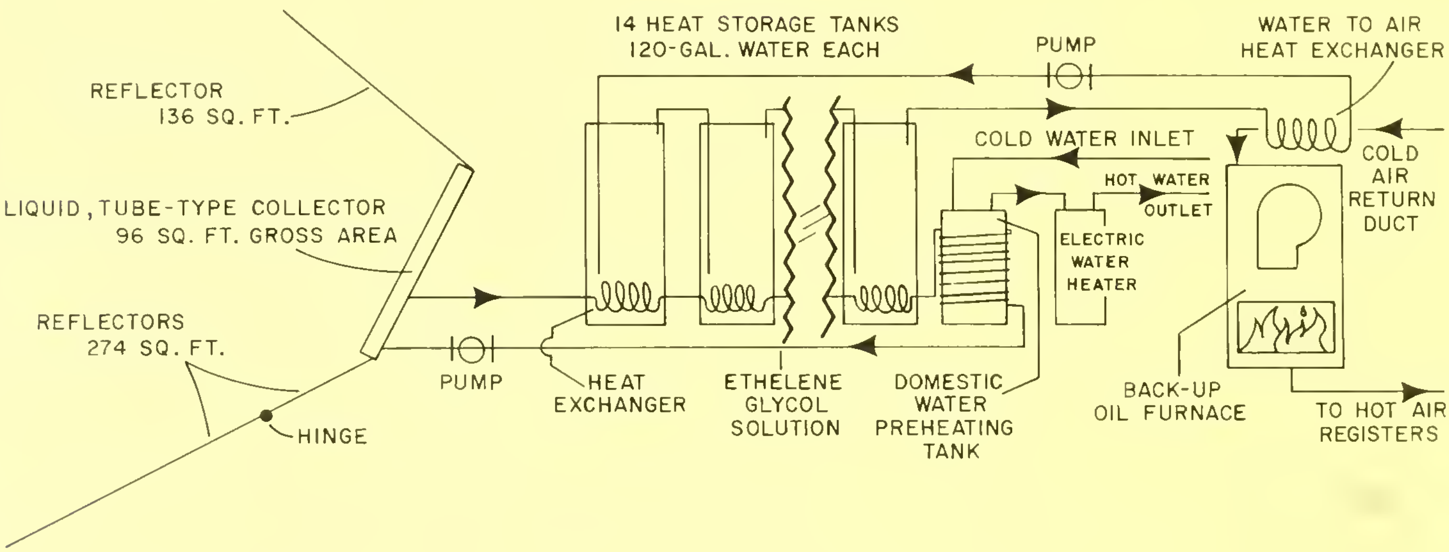
Orville and David Oien — Solar Space and Water Heating — Conrad, Montana

MODIFICATION: The heat exchange systems had originally been planned to transfer heat from the water storage tanks to the cold air plenum of the oil-burning furnace. However, even though the room housing the tanks was well insulated, it was found that considerable stored heat was being lost there. The owner decided that the resultant heat loss could be corrected by eliminating the heat exchanger in the cold air plenum and moving the storage tanks to a different part of the home. Placing the tanks into a special crawlspace which is insulated on the outside and venting the warmed air directly into the living space, (using the passive principle of convection), will greatly improve system efficiency. Since the tanks act as radiators, no plumbing into a circulating system is needed, so additional labor and material costs can be avoided.

Another advantage of eliminating the heat exchanger is that a lower grade of heat is usable. The water for the heat exchanger has to be at least 100 degrees F. in order to transfer a significant amount of heat from the water to the air forced through the cold air plenum. By using the warm storage room air, stored heat as cool as 70 degrees F. can be used to bring the living space temperature to 65 degrees. There is no time lag in heat transfer because the transfer is direct, and the use of convection does not require fans to move the warmed air, since warm air naturally rises.

ECONOMIC EVALUATION: Initial system cost was $7,987.21, of which $7,276 was covered by grant funds. For 96 square feet of collector, the system cost was $83.20 per square foot, but including the area added by the reflectors the price would be ½ to ⅓ this figure, as low as $37.73 per square foot. Projected annual savings on space/water heating were expected to be $230 for the first year of operation. Rising fuel oil prices will increase savings realized with solar heat. The payoff period estimated by the owners is twenty years for an investment of $8,000. Further evaluations of the system will help verify and give greater definition to this information.

VIEWING TIMES: The project can be seen during the day on the first Sunday and Monday of each month or by appointment. Call 278-3355 or write Orville Oien, RR3, Box 89, Conrad, MT 59425.



HOUSE	
General:	Existing single family dwelling, forced air oil-burning furnace
Floor area:	1550 square feet
Calculated heat loss:	11,575 BTU's per Degree Day plus domestic hot water heat load
COLLECTOR	
Transfer fluid:	50-50 mixture, ethylene glycol and water
Tilt:	63 degrees from horizontal
Orientation:	True south, on roof of house
Size:	98 square feet gross surface area, plus 450 square feet reflective surface
Circulation rate:	4 gpm (2.45 gph per square foot of collector)
Construction:	Thermopane patio door glazing: tube-in-plate Roll-Bond absorber by Olin Brass; insulation and plywood back. Reflectors: delta-rib, aluminum roofing
STORAGE	
Medium:	Water, 1680 gallons
Container:	120 gallon tanks, wrapped with 6 inches fibreglass insulation
Relation to collector:	17 gallons per square foot of collector area

Renewable ENERGY project spotlight

MONTANA DEPARTMENT OF NATURAL RESOURCES & CONSERVATION
RENEWABLE ENERGY PROGRAM
ENERGY PLANNING DIVISION 32 SOUTH EWING HELENA, MONTANA 59601 DNRC

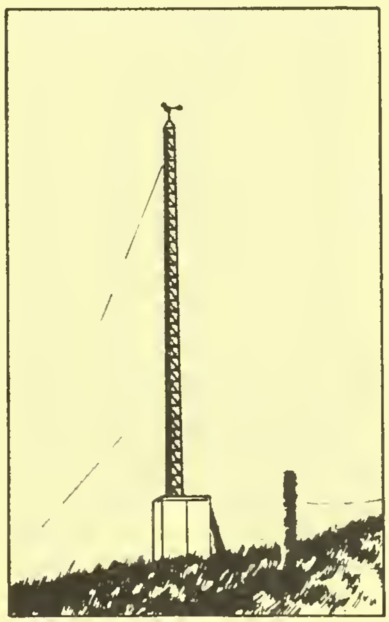
: 1980

Wind Monitoring at Tracy

LOCATION: Tracy, Montana, 5 miles east of Great Falls on Highway 200, then 6 miles south on Highway 227.

PURPOSE: This project was designed to establish the wind energy resource at the Tracy site. A short period of monitoring established a correlation with the wind resource at the Great Falls International Airport where long-term data is available. Mathematical extrapolation was done from this basis to make long-term wind energy projections at the Tracy site.

PROJECT: The project consisted of monitoring the test site and recording the information needed to establish its power generation potential by making continuous measurements during April 1977. The weather monitoring instruments consisted of a three-cup anemometer, a temperature sensor and a wind direction vane mounted atop a 38-foot guyed tower. The equipment shed, a 4-foot-square, weather-tight building at the base of the tower, enclosed the electronic digital equipment and a second temperature sensor. (Because this equipment is temperature sensitive, only data recorded with equipment temperature in a specified range was used.)



The electronic equipment converted signals from all the instruments to give: (1) temperatures in degrees Fahrenheit, (2) instantaneous wind speed in miles per hour, (3) cumulative run of wind in miles and (4) wind direction in 8 quadrants (45 degrees each). This digital interface system operated on 24-volts DC, supplied by two 12-volt automotive batteries. (The batteries allowed the data monitoring equipment to operate continuously, uninterrupted by power failures.) As an added precaution, all of the converted digital data was recorded on punched paper tape instead of being stored electronically.

The recorded data was then compared with data from the weather station on an hour-by-hour basis. Statistical variation between the two sets of data was used to obtain the correlation between the site measurements and the long term wind speed and power measurements at the weather station. The data was fed into a computer for ease of manipulation.

These measurements were then used to help determine the theoretical maximum output (energy density) of a wind generator at the site. The energy density for the month of April at the Tracy site was based on hourly records of cumulative wind flow and on ambient temperature conditions at the top of the 38-foot tower. The weather station's hourly wind speed readings, taken at a tower height of 22 feet at the airport, were assumed to represent cumulative wind flow for the energy density calculations. The weather station data was mathematically corrected to allow for the difference in height between the two towers. Theoretical power, available power, wind speed average and simulated power of a wind machine of a specific size were all predicted, using mathematical formulas and machine performance curves.

FINDINGS: Two important assumptions were made regarding the data taken by the weather station: (1) the instantaneous hourly wind speed readings at the airport were representative of the average wind conditions for that hour, and (2) the recorded data could be height-corrected mathematically to allow for the difference in height between the two towers. Considering that both towers were located in similar terrain (i.e., relatively flat open country), the height correction calculations were considered valid.

The energy density for the month of April at the Tracy site was 114.0 kWh/square meter (m^2). The energy density computed for the airport for April was 113.8 kWh/m^2. Based on these findings, the wind power generation potential of both sites is nearly identical.

The wind power potential was then used to judge the possible performance of a wind system at both locations. Such comparisons are valid only if, as in this case, both locations are nearly identical. The wind electric system used for mathematical simulation was a Dunlite Model 2000. The system was assumed to be sharing the electric load with the existing power company network through a synchronous inverter and receiving optimum use under all operating conditions. Using these assumptions and the measured wind power potential of both sites, the estimated energy production at the Tracy site was 414 kWh per month and that at the Great Falls Airport was 403 kWh per month.

This compares to approximately 600 kWh of use by the average residence that is not using electricity for space heating. Using the assumed wind machine and operating conditions, the energy density at the site would supply about two-thirds of a homeowner's electrical needs, if electrical space heating was not used.

RECOMMENDATIONS AND CONCLUSION: Ordinarily, measuring the wind power generation potential of a given site must be done over a sufficient period of time to establish the seasonal variations and the long-term reliability of the wind resource at the site. However, measurements can be taken over a short term and compared with cumulative data gathered at a weather station, as in this project, if the weather station is in the same wind "avenue" (has the same prevailing wind patterns) and where mountains and other obstructions will not invalidate the correlation. In addition, the grantee noted that weather station data should not be taken at face value; the height of the tower and location of the equipment at the weather station should be checked against the site to ensure that necessary adjustments are made to data, as for height correction. Allowances should also be made in judging wind correlation if the weather station wind sensor is protected by a building.

The grantee also found that using the hourly and daily data of wind speeds (from which energy density and windplant power output are computed) resulted in a more accurate assessment of power generation potential than simply using the average monthly speeds for comparison of the two sites. The average monthly wind speed for the airport was 12.6 miles per hour; at Tracy it was 11.8 miles per hour. Although the Tracy site shows a 6 percent lower average wind speed than the airport location, its measured power generation potential is slightly greater than the airport's. The grantee noted that this finding emphasizes the importance of using frequency distribution measurements of wind speeds for comparing power generation potential between two locations.

12/79